Reducing Data Center cooling energy consumption with accurate measurements

eGuide

VAISALA

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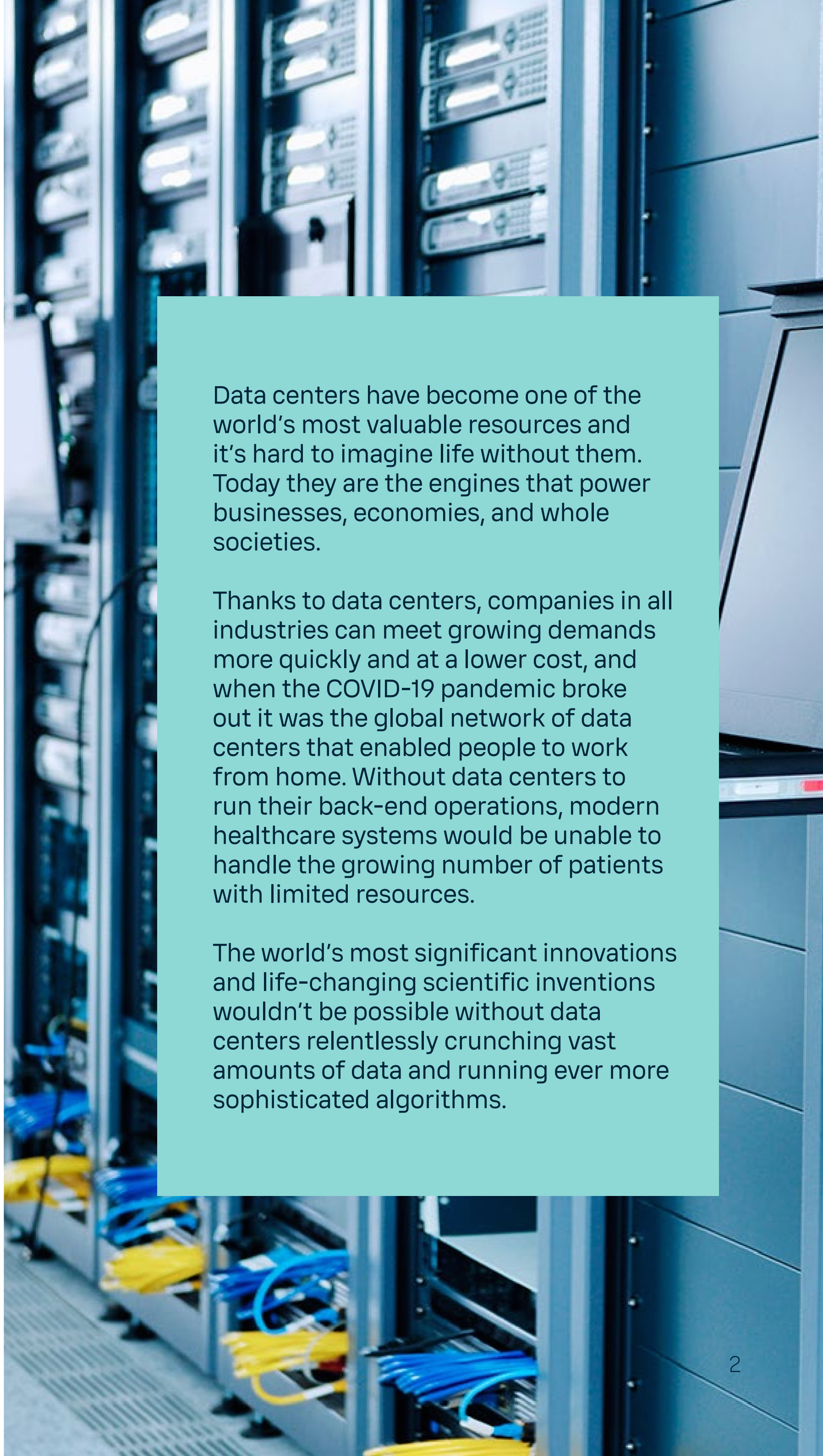


Data centers have become one of the world's most valuable resources and it's hard to imagine life without them. Today they are the engines that power businesses, economies, and whole societies.

Thanks to data centers, companies in all industries can meet growing demands more quickly and at a lower cost, and when the COVID-19 pandemic broke out it was the global network of data centers that enabled people to work from home. Without data centers to run their back-end operations, modern healthcare systems would be unable to handle the growing number of patients with limited resources.

The world's most significant innovations and life-changing scientific inventions wouldn't be possible without data centers relentlessly crunching vast amounts of data and running ever more sophisticated algorithms.

About this guide

Cooling is critical to maintaining temperature and humidity at the optimal level for reliable server operations. However, cooling and air conditioning are second only to IT equipment in terms of power consumption in data centers, accounting for up to 40 percent of the total energy demand. It comes as no surprise, then, that even the tiniest variations in cooling temperature can have a significant impact on the overall running costs of a data center.

A recent case study found that overcooling a data center by a mere 1 °C (1.8 °F) can increase cooling energy costs by up to 8.5 percent. For a 50 MW data center this translates into an additional 2.1 million euros in energy costs over ten years. Thus, the accuracy of the temperature measurement instruments controlling the cooling system is of utmost importance. Low accuracy of, for example, ±0.5–1.0 °C could result in millions of euros of avoidable costs and tons of unnecessary carbon dioxide (CO_2) emissions. This can be avoided by using instruments with a high accuracy of, say, ±0.1 °C.

This guide explains how data centers can reduce their energy costs by using high-accuracy measurements. It is divided into four sections

1. Introduction
Data center trends and the critical role of cooling and measurements

2. Why Measurement Accuracy Matters
How it affects data center costs and risks

3. Case Study
Measurement accuracy vs. cooling energy costs in a data center

4. How to Increase Measurement Accuracy
Five characteristics of high-accuracy measurements

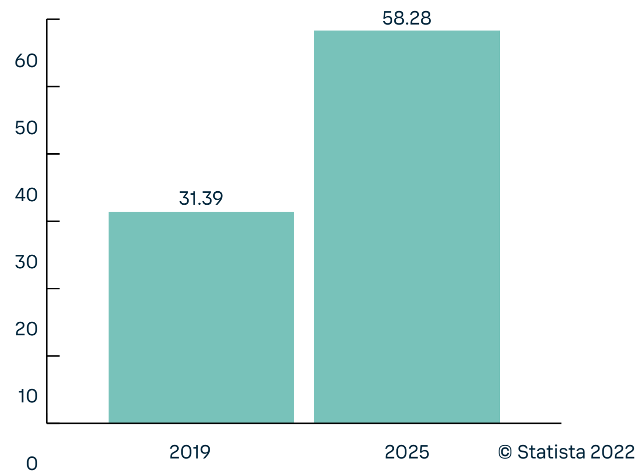
About Vaisala

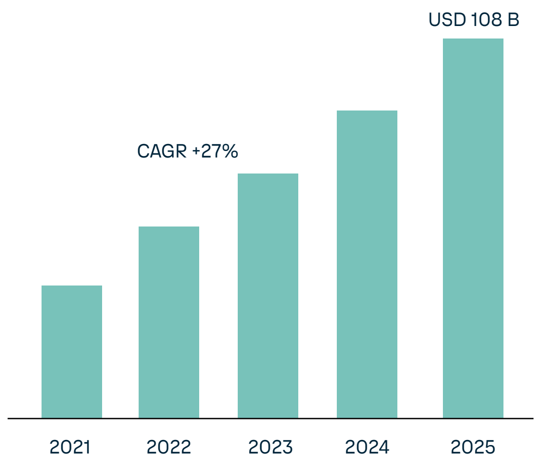
This guide is produced by Vaisala, a global leader in indoor and outdoor environmental and industrial measurements. With 85 years of pioneering measurement technologies, Vaisala provides the world's most accurate and innovative measurement solutions used in the most demanding conditions on earth and in space, helping companies and organizations operate more efficiently and sustainably.

We are the trusted measurement technology provider for data centers of all sizes, including the world's largest hyperscale providers.

1. Introduction

Data Center Market Growth





The irreplaceable role of data centers is reflected in global service and technology markets. The global market for internet data centers is projected to reach USD 143 billion by 2027, up from an estimated USD 59 billion in 2020.

Data center colocation
In 2019, global revenue from the colocation data center market amounted to around USD 31 billion. Industry revenues are expected to increase to over USD 58 billion by 2025. Datacenter colocations are large data centers hosting physical servers owned by customer companies and providing space, security, power, and connectivity.

Hyperscale
The global hyperscale data center market is expected to grow by USD 108 billion during 2021–2025, progressing at a CAGR of 27% during the forecast period. Hyperscale data centers are massive business-critical facilities with highly efficient, robust, and scalable data processing and storage infrastructure.

Growth drivers

What is driving the data center market growth? The answer lies in the intersection of data, artificial intelligence (AI), cloud computing, and global connectivity. These and many other drivers, combined with the unmatched cost-efficiency and time-to-market benefits, ensure continued growth. Distance is no object in the world of data centers because global fiber networks provide unlimited bandwidth to process and store data wherever it is most cost-efficient to do so. More and more countries are embracing digital transformation and offering lucrative tax incentives to attract data center providers, further fueling market growth.

Data
An estimated 2.5 quintillion bytes of data are created every day (2018), and the pace is only accelerating due to the rapid proliferation of computers, smart devices, virtual and augmented reality, and AI applications – all of which demand new data center capacity.

IoT
The global analytics company IDC predicts that by 2025 there could be up to 75 billion IoT devices globally generating up to 79.4 zettabytes of data. A large sha re of the IoT data will be stored and processed in data centers of one form or another.

AI
Artificial intelligence and machine learning rely on vast amounts of data and computing power, which is why data centers are typically used to facilitate their application, reducing time-to-market and upfront investments.

Edge
The need to reduce latency for applications such as industrial control and autonomous vehicles is driving demand for decentralized data centers at the edges of networks typically located on 5G wireless towers, factories, or commercial facilities.

Cloud
Enterprises are increasingly shifting away from on-premises IT applications toward colocated off-premises cloud environments, feeding the growing demand for data center capacity.

Challenges

Despite the virtually unlimited growth opportunities, data center owners, operators, and facility managers are now facing their most complicated challenge ever – meeting customers' growing demands while reducing energy consumption, costs, and carbon emissions.

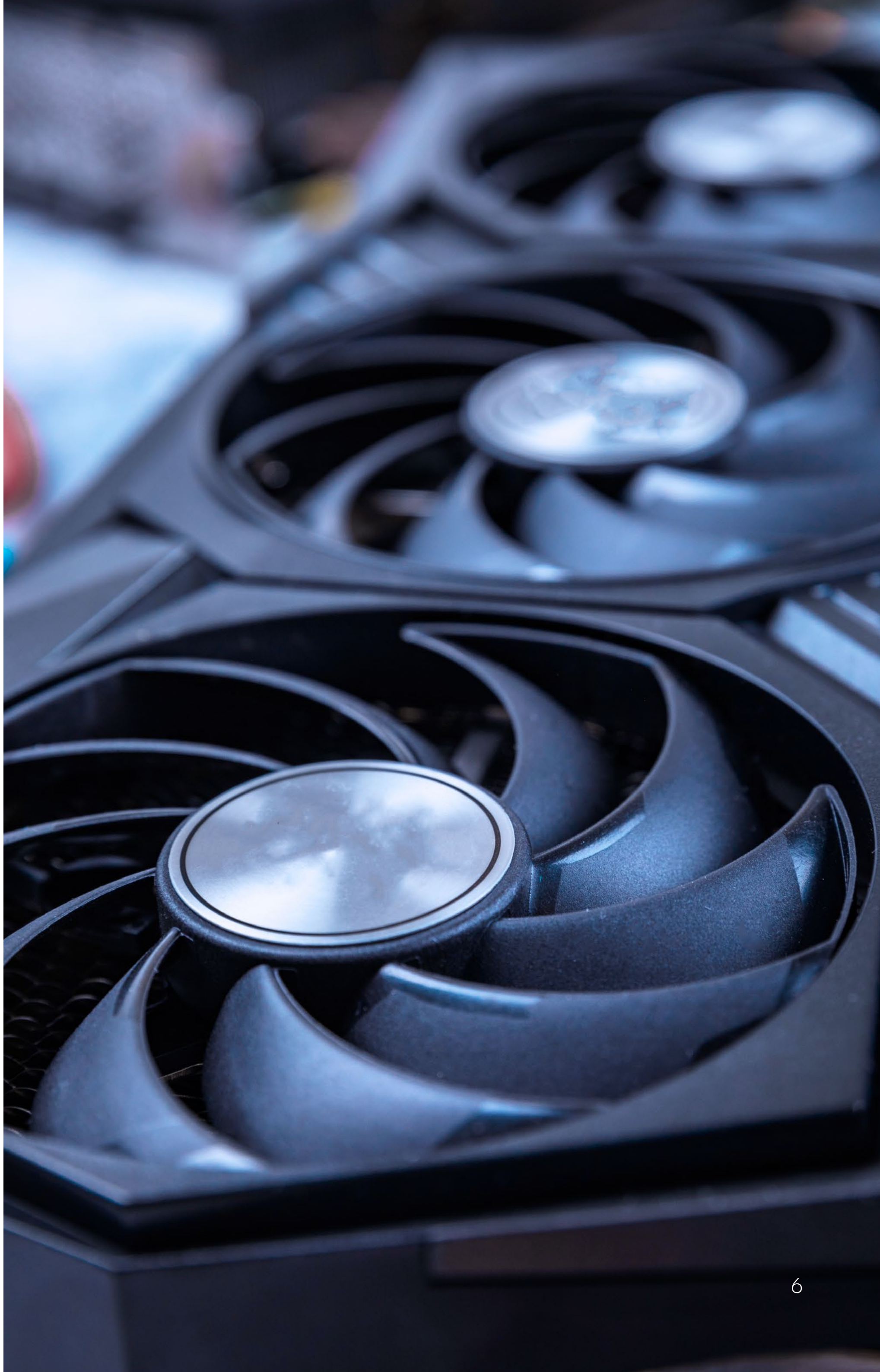
Energy Consumption and Carbon Emissions

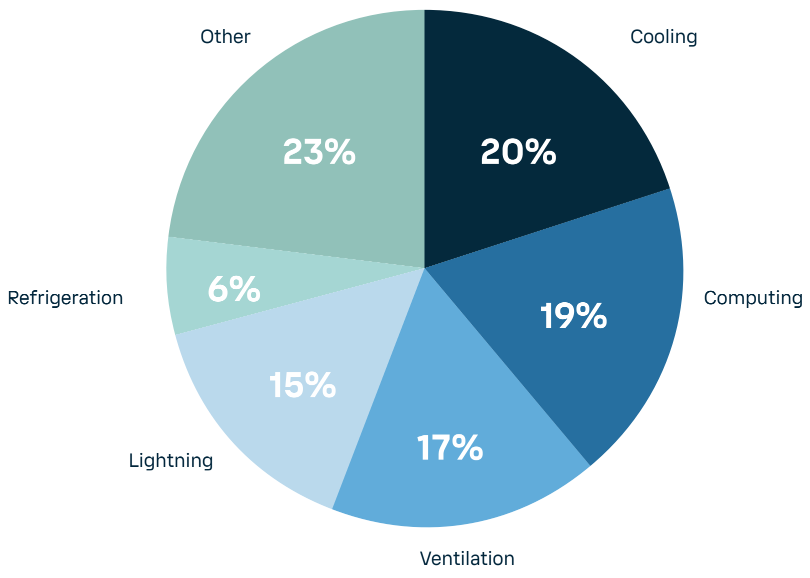
According to the International Energy Agency (2021), in 2020 data centers consumed approximately 200 terawatt-hours (TWh) of electricity, corresponding to nearly one percent of global electricity demand and contributing to 0.3 percent of total global CO_2 emissions. In comparison, aviation generated two percent of total global carbon emissions in the same period. Data centers are increasingly utilizing renewable energy sources, more innovative and energy-efficient cooling infrastructure solutions, and, in regions with favorable climatic conditions, free-cooling techniques to increase their efficiency and environmental sustainability.

Power Density and GPUs

Data centers need a reliable supply of electricity to feed increasingly fast and more power-hungry IT equipment. The average power density continues to increase year on year – currently, it is approximately 7 kW and ranges up to 16–20 kW, and even 100 kW and beyond in centers hosting high-performance computing (HPC) applications. The average rack height is now reaching 45–52 U as centers seek to squeeze more capacity out of every square meter of floor space.

Graphics processing units (GPUs), developed initially for accelerating graphics processing, are increasingly used in data centers for faster processing of machine learning (ML) algorithms. The higher computing power of GPUs presents data centers with a new cooling challenge – a single GPU-accelerated server can produce more than 3 kW of heat.





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Downtime

As data centers process more and more data, the revenue per server increases and along with it the financial risks associated with downtime. A study by the Ponemon Institute found that the respondent data centers experienced an average of 2.4 facility shutdowns and ten isolated downtime events in 2020, with an average outage duration of 138 minutes. To maintain 99.999 percent availability, facility managers are fighting an ongoing battle to identify the optimal cooling and air conditioning level to solve their power and heat management challenges.

Cooling and Air Conditioning

Data centers must constantly challenge the laws of thermodynamics. Taller and taller racks packed with more and more processing power require ever more efficient cooling and air conditioning because, combined, they account for 40 percent of a data center's total energy consumption. Cooling and air conditioning are the most significant non-IT costs, and thus the primary challenge for data center owners, operators, and facility managers remains how to cool more with less power to reduce costs and CO_2 emissions?

2. Why measurement accuracy matters

What do we mean by measurement accuracy?

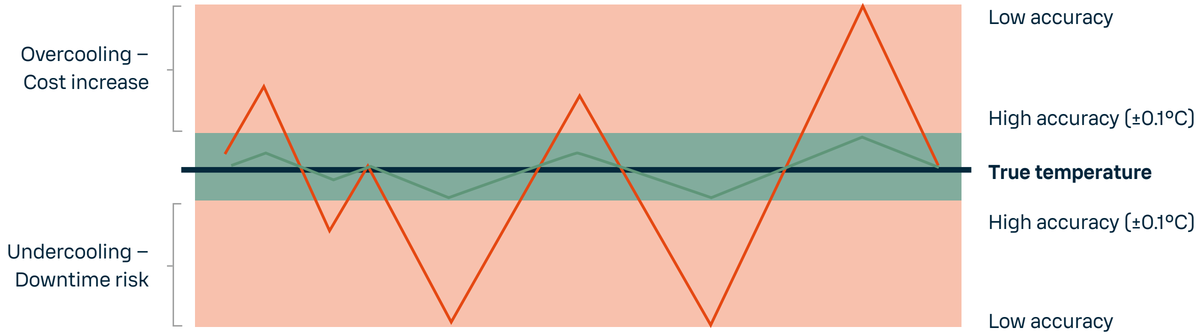
Optimal control over cooling and air conditioning is the key to significant cost savings. However, a cooling system is only as accurate as the measurements used to control it.

The more accurate the temperature and humidity data provided to the automated control system, the more precisely it can adjust cooling and air conditioning and the higher the reductions in energy costs and CO2 emissions.

How measurement accuracy affects data center operation

The lower the accuracy of a measurement instrument, the higher the possible deviation from the actual temperature or humidity in the space being measured, and vice versa.

Vaisala devices are capable of temperature measurement accuracy as high as ±0.1 °C and humidity measurement ±0.8% RH, allowing data centers to accurately control their cooling and air conditioning systems.



Falsely high temperature readings can lead to overcooling, resulting in excessive energy consumption and emissions.

Falsely low temperature readings can lead to undercooling, increasing the risk of IT downtime.

Too dry air can short circuit IT equipment, and the combination of excessive humidity and low temperature can result in condensation.

3. Case study

Measurement accuracy vs. cooling energy costs

Highly accurate temperature measurements can potentially save a significant amount of energy and therefore emissions. But how much can a data center potentially reduce its energy costs by investing in high-accuracy measurement equipment?

This section explains a case study conducted by a leading climate system provider and trusted partner of several data centers worldwide.

The measurements and simulations for three data centers concluded that a mere 1 °C decrease in delta temperature (T) could increase annual cooling energy costs by up to 8.5 percent per 1 megawatt (MW) of IT equipment load. This means that temperature measurement instruments with low accuracy, e.g., ±0.5-1.0 °C, could unnecessarily increase cooling energy consumption and increase costs significantly.

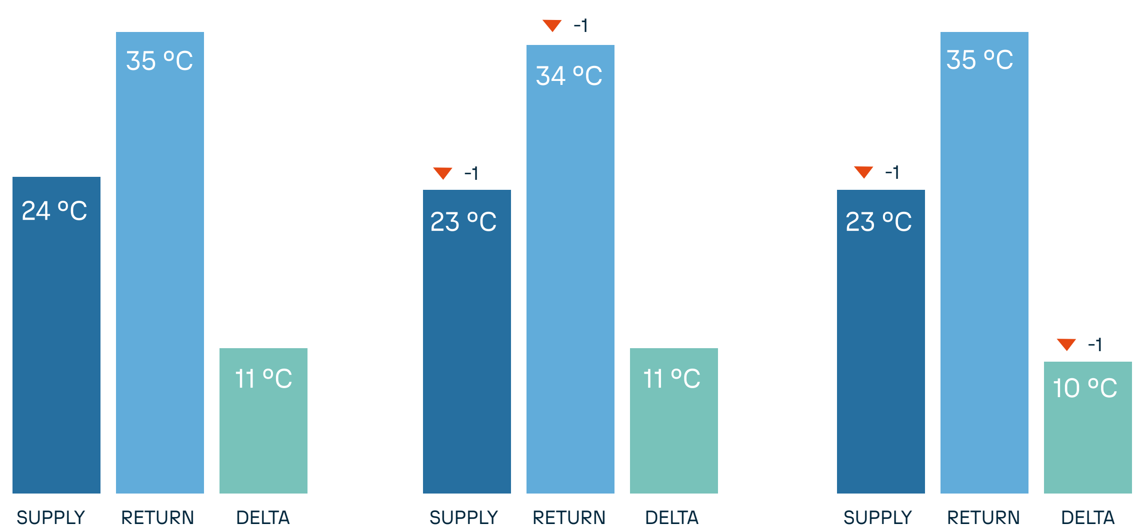
Three cooling cases

The case study compares three cooling cases. In case 1, actual measured data forms the baseline. The designed temperatures were changed by 1 °C in cases 1 and 2 using data simulation and modeling to determine how cooling temperature variations can impact energy consumption.

Scenario

The case study was built around a scenario of three data centers located in major European cities, each with a 1 MW IT equipment load and N+1 redundancy.

The data centers operate based on the standard design with cooling units maintaining the supply temperature at 24 °C, return temperature at 35 °C, and delta temperature at 11 °C.



Case 1

The baseline case has a standard data center design with a supply temperature of 24 °C and a return temperature of 35 °C. Delta temperature is 11 °C.

Case 2

The supply and return air temperatures are both reduced by 1 °C. Delta temperature remains unchanged at 11 °C.

Case 3

Return temperature is lowered by 1 °C while supply temperature maintains the same. Delta temperature is decreased by 1 °C.

Results

Figure 1 shows the case study results with annualized cooling energy consumption for the three cases in the three data center locations.

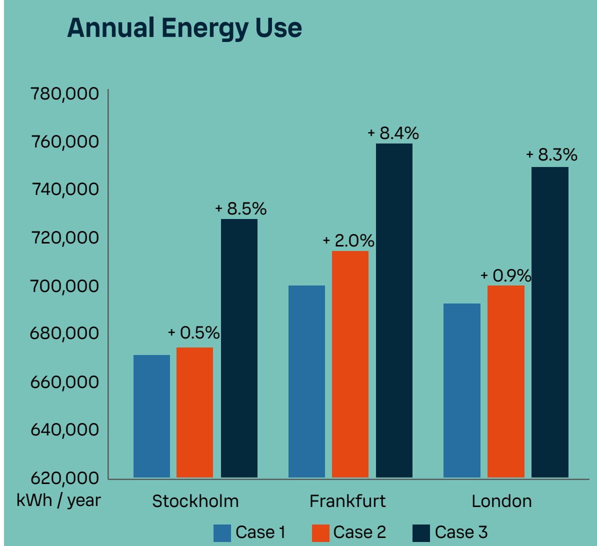
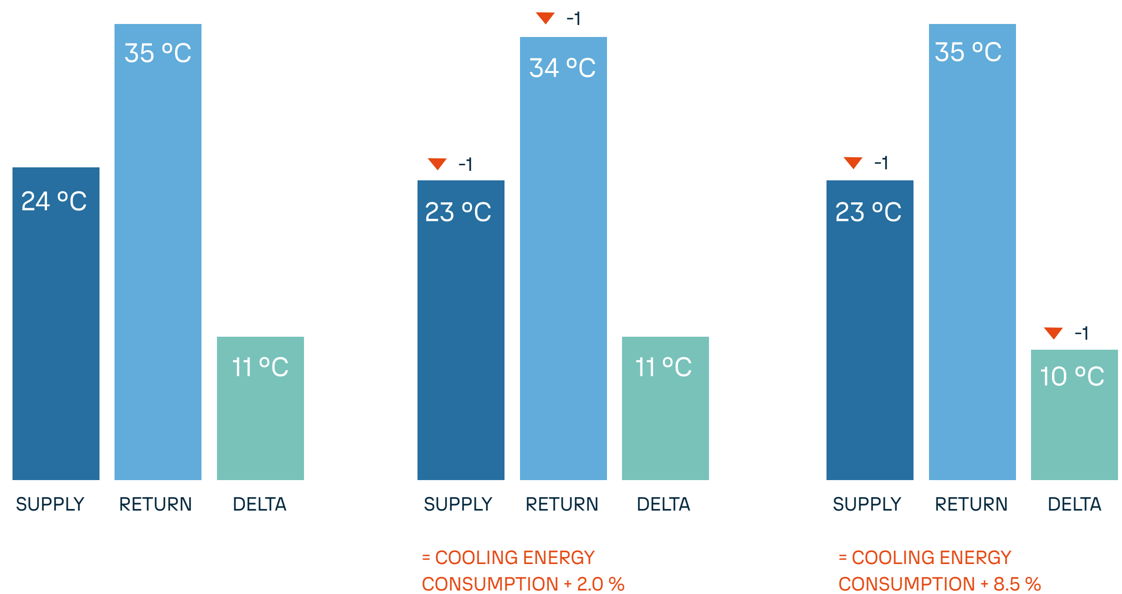


Figure 1. Comparison of annual energy use of three data centers in three case scenarios.



Case 1

The actual cooling energy consumption measured in the data centers with standard design.

Case 2

The supply and return air temperatures were both decreased by 1 °C with the delta temperature maintained at 11 °C.

The data simulation and modeling show a rise of up to 2 percent in annual cooling energy consumption due to the reduction in the supply and return temperatures.

Case 3

The return temperature was decreased by 1 °C while maintaining the same supply temperature.

The simulations in this case clearly show that reducing the delta temperature by just 1 °C can increase data center cooling energy consumption by up to 8.5 percent, or 60 kWh per 1 MW IT load per year.

Cost Impact on data centers

How much can 1 °C overcooling cost to a data center in the long term? Below we present a lifecycle cost analysis for three arbitrary data centers of different sizes using net present value (NPV) calculation with a 7 percent annual discount rate over ten years. The extra cooling energy consumption of 60 kWh per 1 MW IT load per year defined in the case study was multiplied for three typical data center IT loads of 10 MW, 50 MW, and 100 MW. The calculation assumed an electricity price of 0.1€/kWh.

This estimation shows the massive cost impact that 1 °C of overcooling can potentially have on data centers over a period of ten years.

Impact of 1 °C Overcooling

10 MW IT LOAD	50 MW IT LOAD	100 MW IT LOAD
+600 kWh cooling power/year » +0.42 M€ energy cost/10 years	+3,000 kWh cooling power/year » +2.1 M€ energy cost/10 years	+6,000 kWh cooling power/year » +4.2 M€ energy cost/10 years

Conclusions

This case study clearly shows that even the tiniest variations in cooling temperature can have vast cost implications for data centers in the long term. Thus, high-accuracy temperature measurement is of utmost importance to ensure optimal cooling control. Low-accuracy temperature instruments with, for example, a ±0.5-1.0 °C deviation from the actual value could cause enough overcooling to negatively impact data center energy consumption.

Vaisala's high-accuracy temperature and humidity instruments feature industry-leading accuracy of ±0.1 °C, ±0.8% RH, minimizing deviation from the actual values, allowing data centers to control cooling accurately and reduce energy costs.

Learn more about Vaisala's high-accuracy measurement solutions

The accuracy and long-term stability of Vaisala's measurement probes are in the class of their own. The probes deliver repeatable measurement with high resolution, providing you with data that you can rely on, which helps you to make better decisions – over the long term.

The Vaisala Indigo family is a customizable instrument platform designed to improve process measurements. It contains a selection of transmitters, interchangeable smart probes that measure various parameters, and software for easy interfacing and monitoring of data. Choose any probe and connect it with any of the transmitters, or integrate the probes into other systems. The Indigo platform is built on top of Vaisala's self-produced, core sensor technologies.

4. How to increase measurement accuracy?

Five characteristics of high measurement accuracy

How can you achieve high measurement accuracy and maintain it in the long term? How is measurement accuracy defined? It is more than the mere nominal accuracy reading on an instrument's datasheet. In fact, long-term accuracy is a combination of five characteristics: nominal instrument accuracy, stability, calibration frequency, calibration method, and durability. These are discussed below.

1. Nominal Accuracy

Choosing instruments with the highest nominal accuracy is the first step to controlling cooling precisely and reducing energy costs. Vaisala measurement instruments provide industry-leading accuracy of as high as ±0.1 °C for temperature and up to ±0.8% RH for relative humidity.

Vaisala HUMICAP Humidity and Temperature Probe HMP3 is a general purpose probe designed for various industrial processes. With RH accuracy up to 0.8 %RH, temperature accuracy up to 0.1 °C (0.18 °F, temperature measurement range -40 … +120 °C (-40 … +248 °F), the probe provides the best stability, a fast response time, and low hysteresis in a wide range of applications. HMP3 is compatible with Indigo series transmitters and Insight PC software.

2. Stability

Long-term accuracy requires more than superb nominal accuracy, however. An instrument's stability denotes its ability to maintain accuracy over time and prevent drifting, i.e., slow variation of performance characteristics, which gradually reduces accuracy and must be addressed with regular calibration to return instruments to their nominal accuracy level.

By investing in instruments with high stability, you can minimize the impact of drifting and maintain high accuracy for longer. For example, Vaisala's humidity and temperature probe HMP110, based on the renowned HUMICAP® sensor technology, provides high performance, chemical tolerance, and stability, and covers the full humidity range at temperatures from -40 to + 80 °C. Each individually adjusted probe comes with a calibration certificate traceable to NIST (National Institute of Standards and Technology) standards.

3. Calibration Interval

An instrument's calibration interval tells you how frequently it needs to be recalibrated to compensate for drifting. The longer you can extend the calibration interval, the fewer interruptions you have and the more you can reduce maintenance costs.

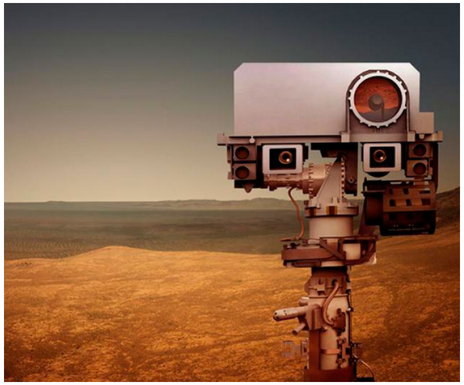
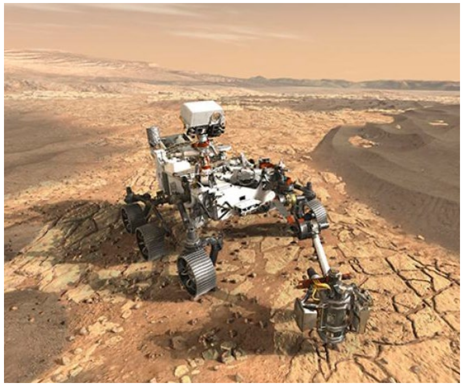
A typical data center can have several hundreds of sensors or more, making calibration a significant maintenance effort. Highly stable instruments such as Vaisala's modular Indigo series and HMT120/130 humidity and temperature transmitters allow you to maintain high accuracy for longer while reducing energy costs and minimizing maintenance efforts. The replaceable measurement probes ensure easy maintenance and eliminate process downtime.

4. Calibration Method

Calibration is important to keep your instruments in perfect tune. In some cases, a simple field check and calibration are sufficient, while some instruments require an off-site laboratory calibration.

With Vaisala's replaceable probes, you can carry out instrument calibration in as little as one minute, minimizing costs and eliminating disruptions. You simply remove the probe to be calibrated, plug in a replacement probe, and continue measuring. This significantly reduces calibration time and costs, particularly for a large fleet of instruments.

In addition, Vaisala offers a replacement service for the probes. When needed, you can order new, pre-calibrated probes from a Vaisala service center.

5. Durability

Durability is a crucial characteristic when it comes to maintaining long-term measurement accuracy. Repairing and maintaining instruments in data centers is time-consuming, and confidentiality regulations restrict third-party access to the premises. Vaisala's sensor technology features world-class durability, increasing accuracy in the long term while minimizing disruptions and maintenance needs.

Vaisala's signature durability has been field-proven in the harshest possible conditions, including in space – Vaisala HUMICAP® and BAROCAP® pressure and humidity sensors onboard the Mars Rover Curiosity have been operating continuously for more than eight years without disruption.

Conclusions

Data centers have become an irreplaceable component of modern businesses, societies, and economies, processing and storing data worth billions of dollars every second of every day and moving vast amounts of information around the world to connect people and businesses. However, competition in the global market is intense; therefore data centers must constantly reduce operational costs such as cooling and air conditioning to maintain profitability. Even a tiny 1 °C reduction in cooling temperature can save hundreds of thousands or even millions of euros in energy costs over a 10-year lifecycle.

With Vaisala's highly accurate industry-leading measurement technologies data centers can control cooling accurately, avoiding unnecessary energy costs and reducing their carbon footprint.

» **Contact Vaisala** to learn more about the world's most accurate and stable measurement solutions!

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